Physics 151 Roster No.:__________________________
May 9, 2005

Score:______________________________

Final Exam, Part A

Exam time limit: 120 minutes. You may use calculators and both sides of 2 sheets of notes, *handwritten only*. Closed book; no collaboration. For multiple-choice questions, circle the letter of the one best answer (unless more than one answer is asked for).

Physical constants:

$g = 9.81$ m/s^2 $G = 6.673 \times 10^{-11}$ N·m^2/kg^2

Useful conversions:

1 year = 3.156×10^7 s 1 m^3 = 1000 L 1 atm = 1.013×10^5 Pa

1. (10 pts.) **Convert** the following quantities into the given units. Fill in the blanks. (You do NOT need to show your work.) Use *scientific notation* where appropriate (very large or very small values), and express all final values to *2 significant figures*.

a. 850 MW = ________________________ mW

b. 240 kPa = _________________________ atm

c. 2.0 L = ___________________________ cm^3

d. 1.5×10^8 km = _____________________ μm

e. 19 kg/L = _________________________ g/cm^3

2. (1 pt.) Which ONE of the following is always a **scalar** quantity?

A. velocity D. linear momentum
B. force E. angular momentum
C. acceleration F. kinetic energy

3. (1 pt.) **Power** has the same units as which one of the following?

A. force × speed D. force ÷ time
B. energy × distance E. energy × time
C. force × time F. energy ÷ distance

4. (2 pts.) An object falls freely from rest. The **time** required for it to strike the ground is *proportional* to its:

A. mass D. initial height
B. square root of mass E. square root of initial height
C. square of mass F. square of initial height

5. **a**. (2 pts.) A projectile is launched with initial velocity $\mathbf{v_0}$ at an angle of 35° above the horizontal. The ***y*-component of its initial velocity** is:

A. $0.18\ v_0$
B. $0.30\ v_0$
C. $0.43\ v_0$
D. $0.57\ v_0$
E. $0.70\ v_0$
F. $0.82\ v_0$

b. (2 pts.) If the same projectile is launched on level ground with v_0 = 40. m/s, what **maximum height** does it reach?

A. 27 m
B. 41 m
C. 54 m
D. 68 m
E. 82 m
F. 160 m

6. (3 pts.) Which *ONE or MORE* of the following are true for an object moving in **uniform circular motion**? ***Circle ALL that apply:***

A. constant linear speed
B. constant linear velocity
C. constant angular momentum
D. constant period
E. constant angular acceleration
F. zero work performed

7. (2 pts.) **TRUE or FALSE (T or F):** For any planet in a circular orbit around the Sun…

a. _____ the planet's orbital **period** depends on the planet's mass.

b. _____ the planet's orbital **speed** depends on the planet's mass.

c. _____ the gravitational **force** of the Sun on the planet depends on the planet's mass.

8. (2 pts.) If the acceleration due to gravity at the Earth's surface equals g, what is the **acceleration** due to **gravity** at a distance of 1.5 R_{Earth} from the center of the Earth?

A. $0.44\ g$
B. $0.50\ g$
C. $0.67\ g$
D. $0.71\ g$
E. $0.82\ g$
F. $0.90\ g$

9. (2 pts.) A solid sphere of mass M and moment of inertia $(2/5)MR^2$ is rolling without slipping at speed v. Its **total kinetic energy** is:

A. $0.25\ Mv^2$
B. $0.30\ Mv^2$
C. $0.50\ Mv^2$
D. $0.70\ Mv^2$
E. $0.75\ Mv^2$
F. $0.90\ Mv^2$

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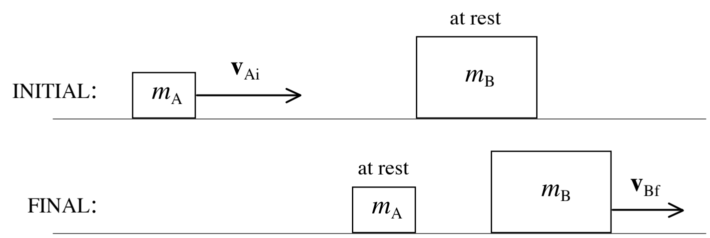
Final Exam, Part B

For multiple-choice questions, circle the letter of the one best answer (unless more than one answer is asked for).

10. Two masses collide exactly head-on (one-dimensional collision) on a frictionless surface, as shown at right. Mass *B* starts at rest before collision, and Mass *A* ends at rest after collision. Masses: $m_A = 1.0$ kg and $m_B = 4.0$ kg.



a. (2 pts.) If the velocity of m_B after collision is $v_{Bf} = 2.0$ m/s to the right, what was the **velocity of m_A before collision, $\mathbf{v}_{Ai}$**?

A. 6.0 m/s
B. 7.2 m/s
C. 8.0 m/s
D. 9.0 m/s
E. 10. m/s
F. 12 m/s

b. (1 pt.) The above collision is:

A. **elastic**
B. **inelastic**

c. (2 pts.) If the two masses are in contact for 5.0 ms, what is the **average force** that each mass exerts on the other?

A. 16 N
B. 80 N
C. 240 N
D. 1600 N
E. 8000 N
F. 24,000 N

d. (1 pt.) If m_A had approached with a *larger initial velocity* v_{Ai} than its velocity above, in which **direction** would m_A move after collision?

A. continue to the right
B. remain at rest
C. rebound to the left

11. (1 pt.) **Hooke's Law** says that, for a simple harmonic oscillator, which one of the following is true?

A. At a given displacement from equilibrium, the velocity is proportional to the displacement.
B. At a given displacement from equilibrium, the restoring force is proportional to the displacement.
C. The displacement of the object starts at zero and grows without bound.
D. Elastic potential energy remains constant at all displacements from equilibrium.

12. a. (1 pt.) If the **mass** at the end of a spring is **doubled**, the system will:

A. oscillate at lower frequency
B. oscillate with the same frequency as before
C. oscillate at higher frequency

b. (1 pt.) If the **initial displacement** of a mass on a spring is **doubled**, but the mass is not, the system will:

A. oscillate at lower frequency
B. oscillate with the same frequency as before
C. oscillate at higher frequency

13. (1 pt.) **Hertz** are mathematically equivalent to:

A. 1/meters
B. meters
C. meters/second
D. seconds
E. 1/seconds
F. 1/seconds^2

14. (1 pt.) If you apply a periodic push to a frictionless pendulum, and your pushing frequency is very close to the natural frequency of the pendulum, which **one** of the following will occur?

A. The pendulum's natural frequency will increase over time.
B. The pendulum's natural period will increase over time.
C. The pendulum's amplitude of oscillation will increase over time.
D. The pendulum's maximum speed will diminish over time.

15. If you blow across the open end of a 33-cm-long tube whose other end is closed, you can excite standing sound waves inside the tube, creating a loud tone. The speed of sound in air is 330 m/s.

a. (2 pts.) What is the **frequency** of the *fundamental* mode of oscillation?

A. 33 Hz
B. 67 Hz
C. 120 Hz
D. 250 Hz
E. 330 Hz
F. 500 Hz

b. (2 pts.) If you blow harder, you can create a different, higher-pitched tone: the *1st overtone*. Its **frequency** is equal to the fundamental frequency **multiplied by**:

A. 1.33
B. 1.41
C. 1.5
D. 1.67
E. 2
F. 3

c. (1 pt.) If you *shorten* the column of air inside the tube by partially filling the tube with water, what will happen to the **frequencies** of the fundamental and 1st overtone?

A. become higher
B. remain unchanged
C. become lower

16. (2 pts.) All of the following are true EXCEPT which **one**?

A. Sound waves are longitudinal oscillations.
B. The speed of a sound wave is independent of its wavelength or frequency.
C. The frequency of a sound wave corresponds to the "volume" that we hear.
D. Standing waves on violin and guitar strings are transverse oscillations.

17. (1 pt.) Three Great **Conservation Laws** we learned this semester are: Conservation Of…

A. Gravitation, Electromagnetism, and Nuclear forces
B. Work, Heat, and Energy
C. Force, Momentum, and Torque
D. Elastic Potential Energy, Gravitational Potential Energy, and Kinetic Energy
E. Energy, Momentum, and Angular Momentum
F. Energy, Gas, and Water

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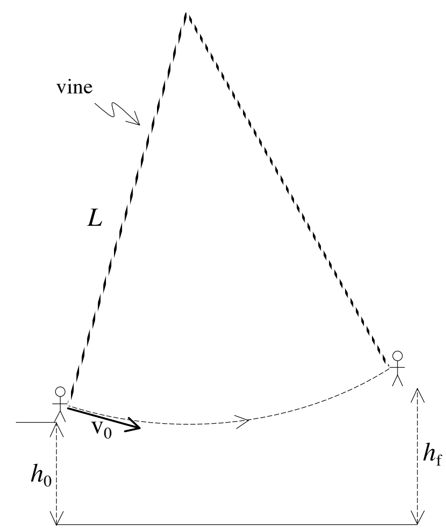
Final Exam, Part C

Show your work on all free-response questions. Be sure to use **proper units** and **significant figures** in your final answers.

1. Tarzan, whose mass is 95 kg, grabs a vine of length L = 13 m and negligible mass. He pushes off from a ledge h_0 = 5.0 m above the ground with an initial speed v_0 = 8.0 m/s, as shown. Ignore air resistance for all parts of this question except part (f).



a. (5 pts.) To what maximum **final height h_f** will Tarzan swing?

b. (4 pts.) If Tarzan continues to hold on to the vine and allows himself to swing back and forth several times (without touching the ledge), what will be the **period** of his swings?

c. (1 pt.) At a moment that the vine is *exactly vertical* during one of its swings, the **tension** in the vine is:

A. zero
B. less than Tarzan's weight
C. equal to Tarzan's weight
D. greater than Tarzan's weight

d. (1 pt.) Suppose that Jane, whose mass is 55 kg, had grabbed the vine at the start of this problem instead of Tarzan. If she pushes off from the same ledge at the same speed as Tarzan, her maximum **final height h_f** would be:

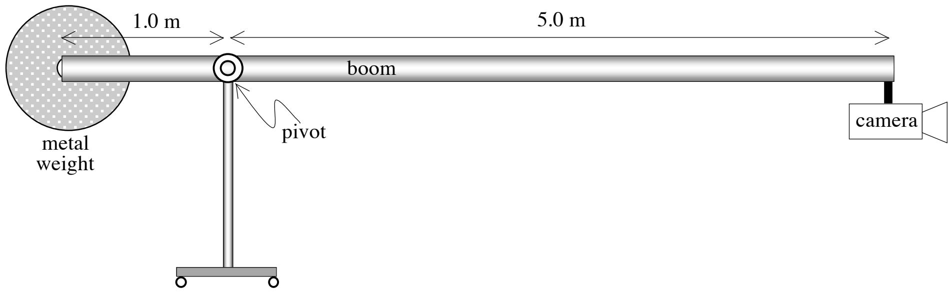
A. less than Tarzan's
B. the same as Tarzan's
C. more than Tarzan's

e. (1 pt.) If Jane continues to hold on to the vine and allows herself to swing back and forth several times (without touching the ledge), the **period** of her swings would be:

A. shorter than Tarzan's
B. the same as Tarzan's
C. longer than Tarzan's

f. (2 pts.) If **air resistance** were present during the swings in part (b) or (e), which *ONE or MORE* of the following quantities would **decrease** over time? ***Circle ALL that apply:***

A. speed at bottom of swing
B. height at ends of swing
C. time to complete one swing
D. number of swings per minute



2. A 6.0-meter-long boom has a television camera suspended at its right end, as shown above. When used properly, the weight of the camera (m_c = 8.0 kg) and of the boom itself (m_b = 26 kg) is counterbalanced by an adjustable metal weight mounted at the boom's left end. Assume that the pivot is frictionless, and that the boom has uniform thickness and density.

a. (6 pts.) At present, the boom is exactly horizontal, and an 85-kg metal weight is mounted on the left end of the boom. Calculate the **net torque** about the pivot. (Note that the system is NOT currently balanced.)

b. (1 pt.) The **vector** of the **net torque** you calculated in part (a) is directed:

A. into the page	C. to the right	E. toward the top of the page
B. out of the page	D. to the left	F. toward the bottom of the page

c. (1 pt.) When the entire system is released from rest in its current position, the boom will begin to **accelerate** about its pivot in **which direction**?

A. clockwise
B. counter-clockwise

d. (4 pts.) Suppose that, immediately after it is released, the system accelerates at 0.15 rad/s^2. Calculate the entire system's **moment of inertia**.

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Final Exam, Part D

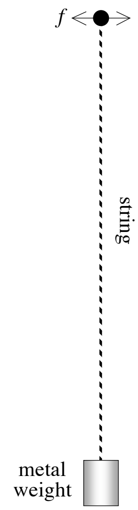
Show your work on all free-response questions. Be sure to use **proper units** and **significant figures** in your final answers.

3. A small research submarine goes on a dive to investigate the summit of Loihi, the undersea volcano off the southeast coast of the Big Island. Assume that seawater is ideally incompressible, so that it has a density of 1030 kg/m^3 at any pressure or depth.

a. (5 pts.) If the summit of Loihi is at an ocean depth of 0.99 km, what is the **pressure** on the outside of the submarine at that depth? Convert your final answer to **atmospheres**.

b. (5 pts.) Suppose we want the submarine to have *neutral buoyancy* when completely immersed in seawater, so that it has a tendency neither to sink nor to float. If the submarine can be approximated by a sphere of radius 1.3 m, what must be the submarine's total **mass** for it to be neutrally buoyant? (*Recall:* $V_{sphere} = (4/3)\pi R^3$.)

4. A metal weight is hung at the end of a string, creating a uniform tension in the string. The string's mass is 50. g and its length is 1.5 m. The top end of the string is fixed to a motor that can vibrate horizontally with a small amplitude at any desired frequency, f.

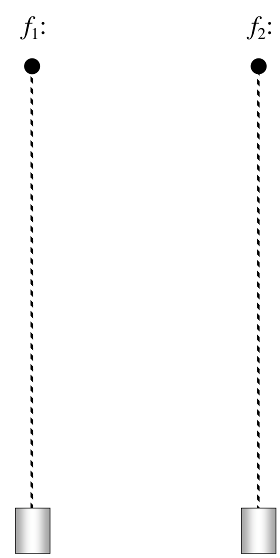


a. (3 pts.) If the speed of all transverse waves along the string is 36 m/s, calculate the **mass** of the metal weight at the end of the string. *Recall:* $v = \sqrt{\dfrac{F_T}{m/L}}$.

The motor's frequency f is started at zero and is slowly increased. Nothing much happens for a while; then, at frequency f_1, a standing-wave mode suddenly appears along the string. As f is increased further, the first mode vanishes, but a second standing-wave pattern appears at frequency f_2. Subsequent standing-wave patterns appear at frequencies f_3, f_4, f_5, etc. (For this entire problem, assume that *BOTH* ends of the string act as though they are *FIXED*.)

b. (6 pts.) Calculate **frequencies f_1 and f_2.**

c. (4 pts.) On the two strings shown at right, **sketch** the standing-wave modes corresponding to both **f_1 and f_2**. Mark ALL **nodes** with heavy dots, including any nodes at endpoints. Again, assume that *BOTH* ends of the string are *FIXED*.



d. (2 pts.) How do **f_1 and f_2 change** if you *increase* the *metal weight* at the bottom of the string?

A. both frequencies increase
B. both frequencies remain unchanged
C. f_1 increases, but f_2 decreases
D. f_1 decreases, but f_2 increases
E. both frequencies decrease

e. (1 pt.) How do **λ_1 and λ_2 change** if you *increase* the *metal weight* at the bottom of the string? Assume that the string does *not* stretch.

A. both wavelengths increase
B. both wavelengths remain unchanged
C. both wavelengths decrease

f. (2 pts.) How many **antinodes** does the string's **4th overtone** have? ____________